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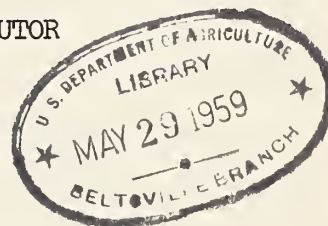
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CHARACTERISTICS OF AN AIRCRAFT DISTRIBUTOR
FOR
GRANULAR MATERIALS^{1/}

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Applying pesticides with aircraft has been accepted as an effective method where speed and accessibility to areas are important (1).^{3/} Since 1949 the successful use of granular insecticides has increased tremendously. These materials have been as effective as sprays for controlling mosquitoes, spittlebugs, soil insects, and corn borers (2, 3, 5, 6, 7, 9). Aircraft applications of granular insecticides where uniformity of distribution was not important have been very successful (4, 9). The potential for utilizing aircraft to uniformly distribute granular insecticides to control corn borers created the need for determining the distribution characteristics of aircraft application equipment.

Granular insecticides from ground applicators have been highly successful for European corn borer control (2, 3, 7). When released above a corn plant, these insecticides are directed to the whorl and leaf axials by the natural funnel formed by the corn leaves. Although the insecticides used for these studies were applied with ground equipment, the properties of granular insecticides indicate adaptability for aerial applications for corn borer control (2, 3, 7, 8, 9, 10).

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^{3/} Numbers in parentheses refer to Literature cited at end of paper.

Ground machines apply granular insecticides in a narrow band over the plant row, while aircraft operating at practical speeds broadcast the material over the entire area. To obtain uniform coverage from aerial broadcasting, a trapezoidal distribution pattern is desirable (8, 10). Adjacent swaths must overlap to result in uniform coverage.

Objectives

Experimental work was undertaken to determine the operational characteristics of a conventional aircraft distributor when used to apply granular materials. An airplane with a dry-materials distributor was made available for testing through the courtesy of an aerial applicator, Charles Laverty of Indianola, Iowa. The distributor, mounted on a Piper PA-18A, was designed by the Aircraft Research Center, Agricultural and Mechanical College of Texas, for use with a variety of dry materials (4, 10).

The objectives of this study were as follows:

1. To determine the distribution pattern of bentonite and attapulgite granules for various flight speeds and altitudes.
2. To determine the effect of wind upon the distribution pattern of bentonite and other granules.
3. To measure pressures and velocities in and about the distributor, so that the performance of the distributor's geometry might be evaluated.
4. To study possible modifications of the distributor to improve the distribution characteristics.

Procedure

The original orifice plate at the bottom of the hopper, equipped with 3 triangular openings for each passageway of the distributor, had insufficient capacity for applying 25 pounds of granular material per acre at 80 m.p.h. flight speed. New plates with one large triangular orifice per passage gave more accurate metering and sufficient capacity.

The distributor was calibrated by weighing the granular material into the hopper, applying the granules over a known area (with an assumed swath width of 40 feet), and weighing the material remaining in the hopper. These calibration runs were made by repeatedly flying over the $\frac{1}{4}$ -mile field where the landing strip was located. The area covered was never less than 2.4 acres.

Wind speed and direction were measured with a vane-type anemometer for each flight. Altitude measurements were obtained by placing a surveyor's transit 200 feet from the line of flight and setting the vertical angle so that the distributor could be seen if the pilot was at the prescribed height of flight plus or minus 3 feet. Several test runs showed that the pilot was able to stay within these limits. Altitude tests were run at 20, 25, 30, and 40 feet, speed tests at 80 and 90 m.p.h., and crosswind tests at 1 to 5 m.p.h. Most tests were run using bentonite clay granules. However, several comparisons of attapulgate and bentonite were made.

Cone-shaped collecting pans 6 inches deep and 26.5 inches in diameter were spaced 4 feet on centers across the swath width perpendicular to the line of flight. The granules collected in these pans were weighed on an analytical balance and the weights obtained were plotted to obtain pattern distribution curves.

To study the effect of discharge passages on the distribution pattern, tests were conducted using single pairs of passages. In an attempt to obtain a more uniform pattern an apron was attached to the rear lower lip of the distributor. Several tests were made with a 9-inch apron that was angled 25° with respect to the bottom surface of the distributor.

A one-sixth scale model of the distributor was constructed and wind tunnel tests were run with and without an apron to study the effect on air pressure and velocity in the throat of the distributor. To study the flow of material through the distributor, the model was placed in a smoke tunnel and photographs were taken while the smoke was flowing through the distributor.

Results

Figure 1 shows representative distribution patterns of attapulgate and bentonite at 80 m.p.h. air speed and a 20-foot altitude. The patterns are very similar. Bentonite tends to have slightly higher peaks and a lower valley in the center of the swath. Effective swath width (maximum swath spacing to give an overall application never less than the lowest concentration in the center of the swath) was somewhat larger for the heavier bentonite.

Speed and height of flight both had some effect on the effective swath width obtained. Figure 2 shows the effective swath widths obtained at speeds of 80 and 90 m.p.h. at various altitudes. Flying at 90 m.p.h. tended to increase the swath width as compared with a flight speed of 80 m.p.h. Height of flight had only a slight effect on swath width when

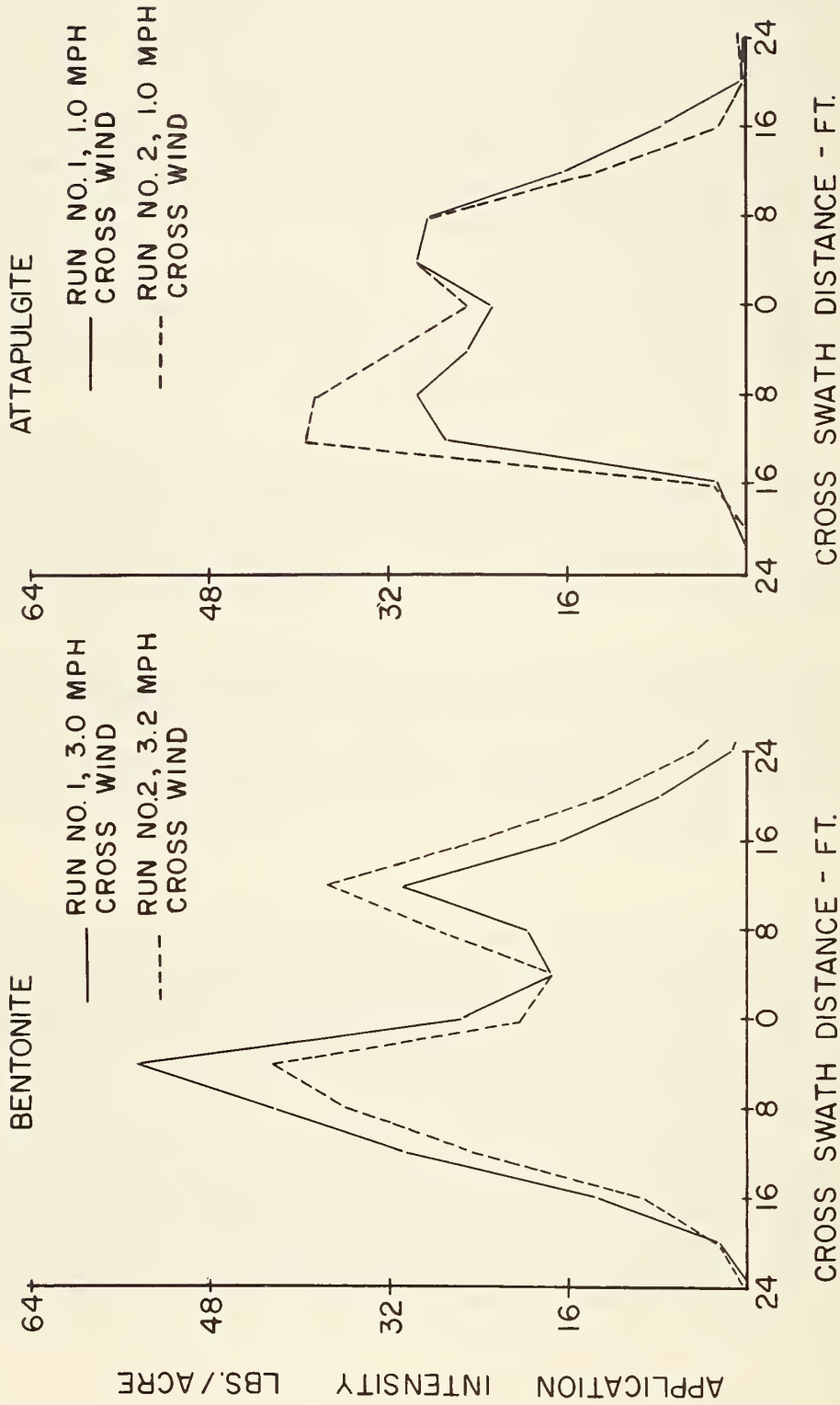


Figure 1. Representative distribution patterns of bentonite and attapulgite applied at 80 m.p.h. and 20 ft. altitude.

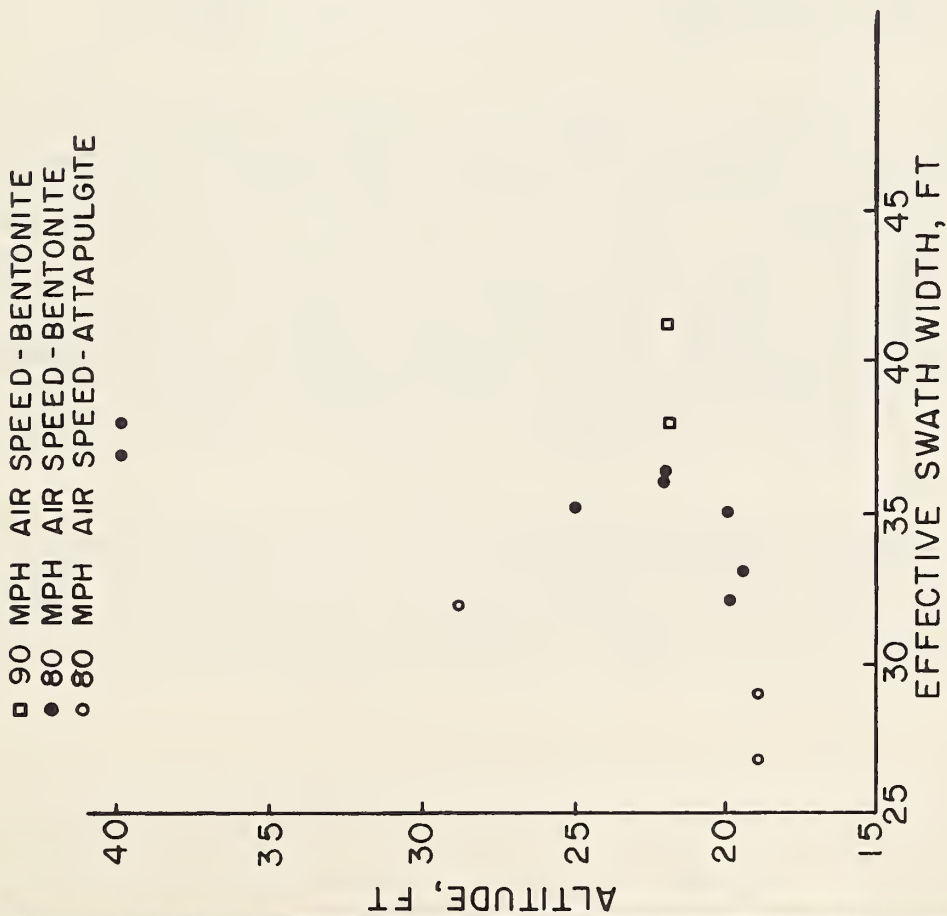


Figure 2. Effect of altitude and speed of flight on swath width.

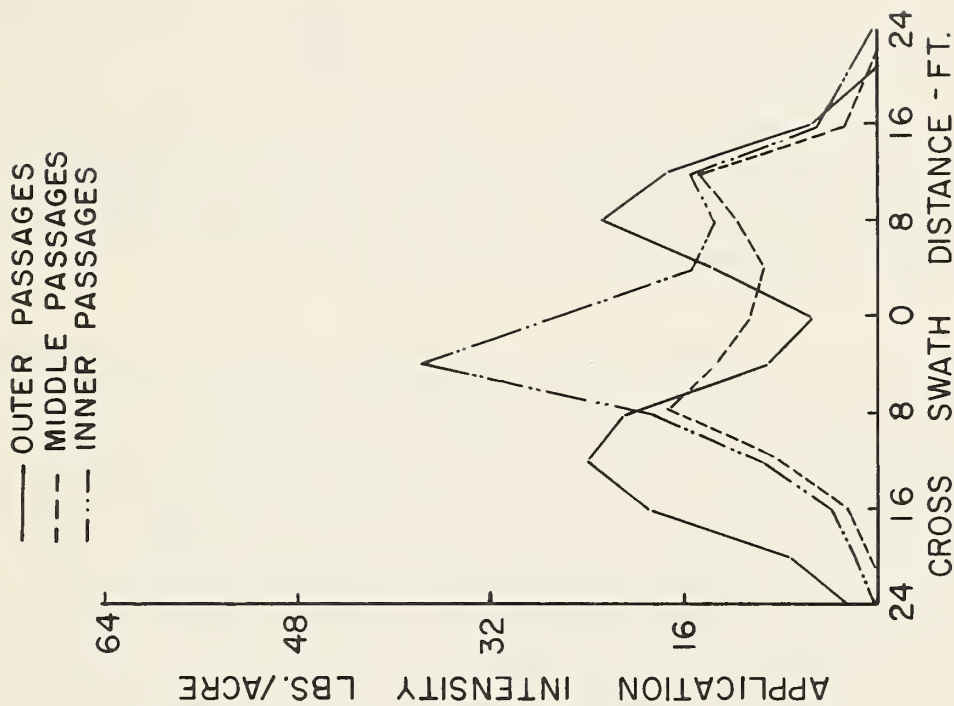


Figure 3. Distribution patterns from pairs of distributor passages.

bentonite was used. However, the lighter attapulgite tended to have a wider swath width as the altitude was increased.

Both materials were affected by crosswinds. The shift in pattern where the low point was used as a center was larger for attapulgite than for bentonite. As expected, the higher altitude flights were more seriously affected by crosswinds. With crosswinds of 5 m.p.h. patterns were shifted as much as 16 feet. Under gusty conditions it was extremely difficult to obtain uniform coverage.

Because of the characteristic two-peaked, low-centered patterns, tests were run using pairs of distributor passageways to study the possible distributor modification that would improve the pattern. Samples of patterns from pairs of passageways are shown in figure 3. The deposit pattern for the outside pair of passages was double-peaked with high concentrations on the left and a very low deposit in the center with a swath width equal to that obtained with all passages. The middle passages showed a narrower swath width with less pronounced peaks. The inside pair of passages were designed to take advantage of the propwash and move a heavy deposit from the right to the left side. This occurred, but there was a low spot in the pattern that coincided with the low center from the outside passages. The left peak was considerably higher than the right as a result of the propwash. Adding the distribution deposits obtained from the inner, middle, and outside passages together gives a deposit curve similar to figure 1. It appears that a major design change is necessary to eliminate the double peaked deposit that is heavy on the left side.

Windy conditions (crosswinds of 5 to 7 m.p.h.) made it difficult to obtain accurate deposit patterns after the 9-inch apron had been attached to the distributor. The data obtained showed no substantial improvement over the runs made without the apron. To study the velocities and pressures occurring in the distributor with and without an apron, a plastic model of the distributor was subjected to wind tunnel tests. Pressure readings taken in the throat of the distributor at the entrance of each passageway were lower than pressures of the free stream. Velocities at all points in the throat were higher than the approach velocity. These data establish a definite venturi action for the distributor. Attaching a model apron to the model distributor tended to increase the velocity and decrease the pressures in the distributor throat.

The model distributor was tested in a smoke tunnel where jet streams of smoke were forced through each of the passageways. Photographs showing the flow of these smoke jets through the distributor indicated the need for further streamlining the distributor to obtain

a more uniform distribution. The jets going through the outside passages follow the contours of the distributor quite well and are dispersed in the center of the rear opening, indicating a uniform discharge. In the middle passages the jets are not discharged in the center but more to the right side. The jet located in the center appeared to flow heaviest on the left side. Although the propwash was predominantly responsible for the heavy deposit on the left side, the smoke jets on the model indicate that some correction could be made by directing the flow of material more to the right on the inner passages.

Summary and Conclusions

Distribution patterns were obtained using a dry materials aircraft distributor on a Piper PA-18A to distribute attapulgite and bentonite granules at various altitudes and flight speeds with crosswinds of 1 to 5 m.p.h. Patterns were also obtained for single pairs of passages in the distributor and when a 9-inch apron was attached to the distributor. A model of the distributor was subjected to wind and smoke-tunnel tests to determine pressures and velocities occurring in the throat of the distributor and to observe the flow of smoke through the distributor. The conclusions drawn from these tests are as follows:

1. Distribution patterns for bentonite and attapulgite were similar, both having two peaked configurations.
2. The effective swath width obtained tends to be slightly greater for both materials with increased altitude. The average swath width was 34 feet for a 19- to 22-foot altitude range at an air speed of 80 m.p.h.
3. Crosswind displaces the distribution pattern of bentonite 2.3 feet per mile per hour for a 19- to 22-foot altitude range, and attapulgite slightly more.
4. Considering high effective swath width, uniform distribution, and small lateral pattern displacement by wind as desirable attributes, airplane application of granular materials in these tests was most successfully conducted at an air speed of 80 m.p.h. and an altitude of approximately 20 feet.
5. It did not appear possible to fill in the center valley of the distribution pattern for all wind conditions with equal material flow through each of the inner pair of distributor passages only.

6. A 9-inch apron mounted the length of the rear lower lip of the distributor did not improve the distribution pattern.

7. Pressure in the throat of the distributor is negative. Air velocity in the throat of the distributor is 1.1 to 1.4 times higher than the air approach velocity.

8. The left, inner channel of the distributor tested was relatively ineffective in displacing material to the right to correct for the propeller slipstream.

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